/ **Marley Sigma F Series** Cooling Tower /

Engineering Data & Specifications

SPX
COOLING TECHNOLOGIES

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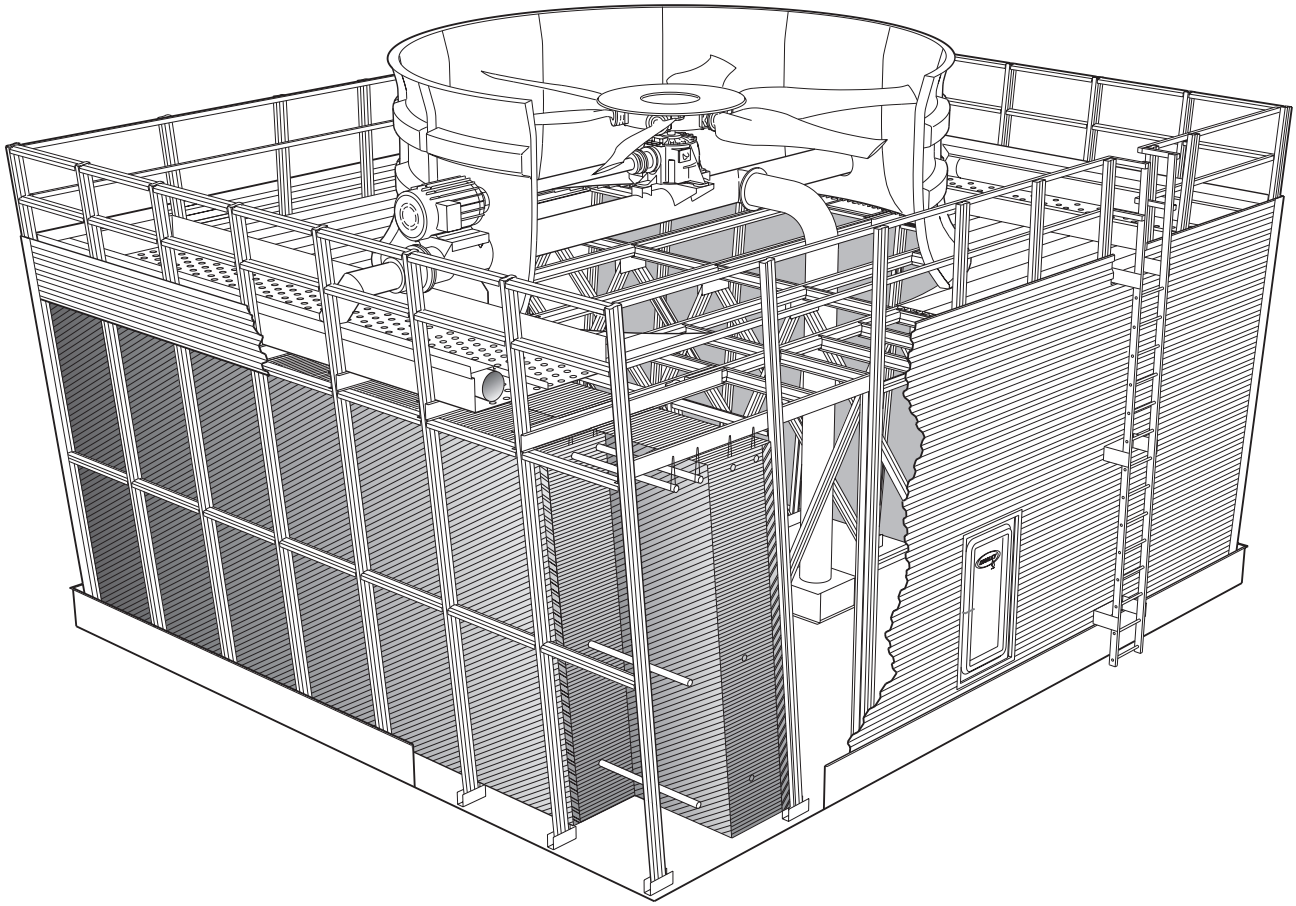


The Sigma F Series is a field-erected, crossflow, fiberglass-structure cooling tower designed to serve normal air conditioning and refrigeration systems as well as medium sized industrial loads. Evolving from the crossflow concept of cooling tower pioneered by Marley in 1938, and incorporating over 65 years of design advancements, the Sigma F Series represents the current state of the art in this cooling tower category.

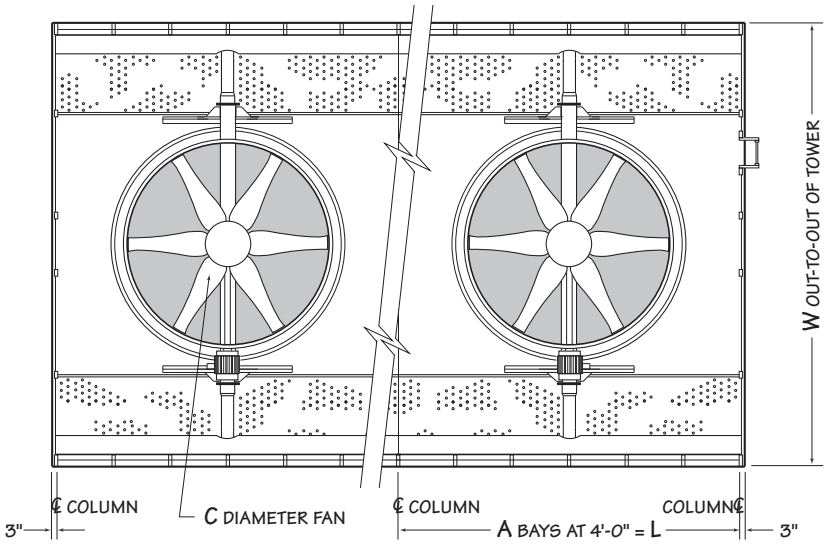
This booklet not only relates the language to use in describing an appropriate Sigma F Series cooling tower—but also defines why certain items and features are important enough to specify with the intention of insisting upon compliance by all bidders. The left hand column of pages 12 through 27 provides appropriate text for the various specification paragraphs, whereas the right hand column comments on the meaning of the subject matter and explains its value.

Pages 12 through 19 indicate those paragraphs which will result in the purchase of a cooling tower which will not only accomplish the specified thermal performance, but which will include normal operation and maintenance-enhancing accessories and features. It will also incorporate those standard materials which testing and experience has proven to provide best results in normal operating conditions.

Pages 20 through 27 provide some paragraphs intended to add those features, components, and materials that will customize the tower to meet the user's requirements.

Space does not permit definition and explanation of all of the possible options that can be applied to the Sigma F Series. SPX Cooling Technologies realizes that you, the purchaser, must be happy with the tower's characteristics, and we are prepared to provide—or provide for—any reasonable enhancement that you are willing to define and purchase.

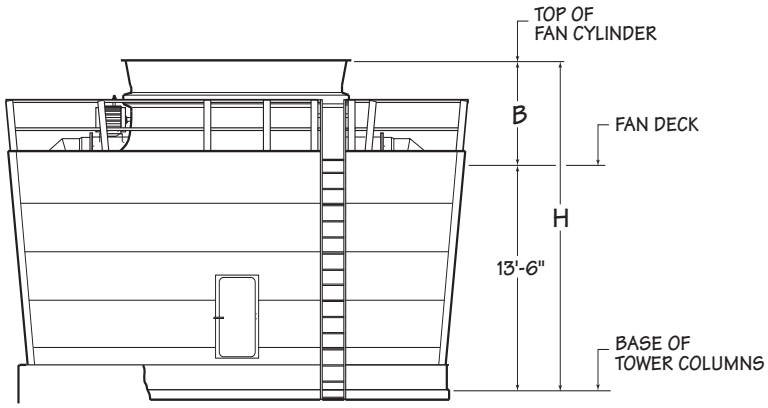
Your needs will become part of the continuing improvement of this product line.



TOWER PLAN

Use this data for preliminary layouts only. Obtain current drawing from your Marley sales representative.

The UPDATE web-based selection software — available at spxcooling.com — provides Sigma F Series model recommendations based on customer's specific design requirements.

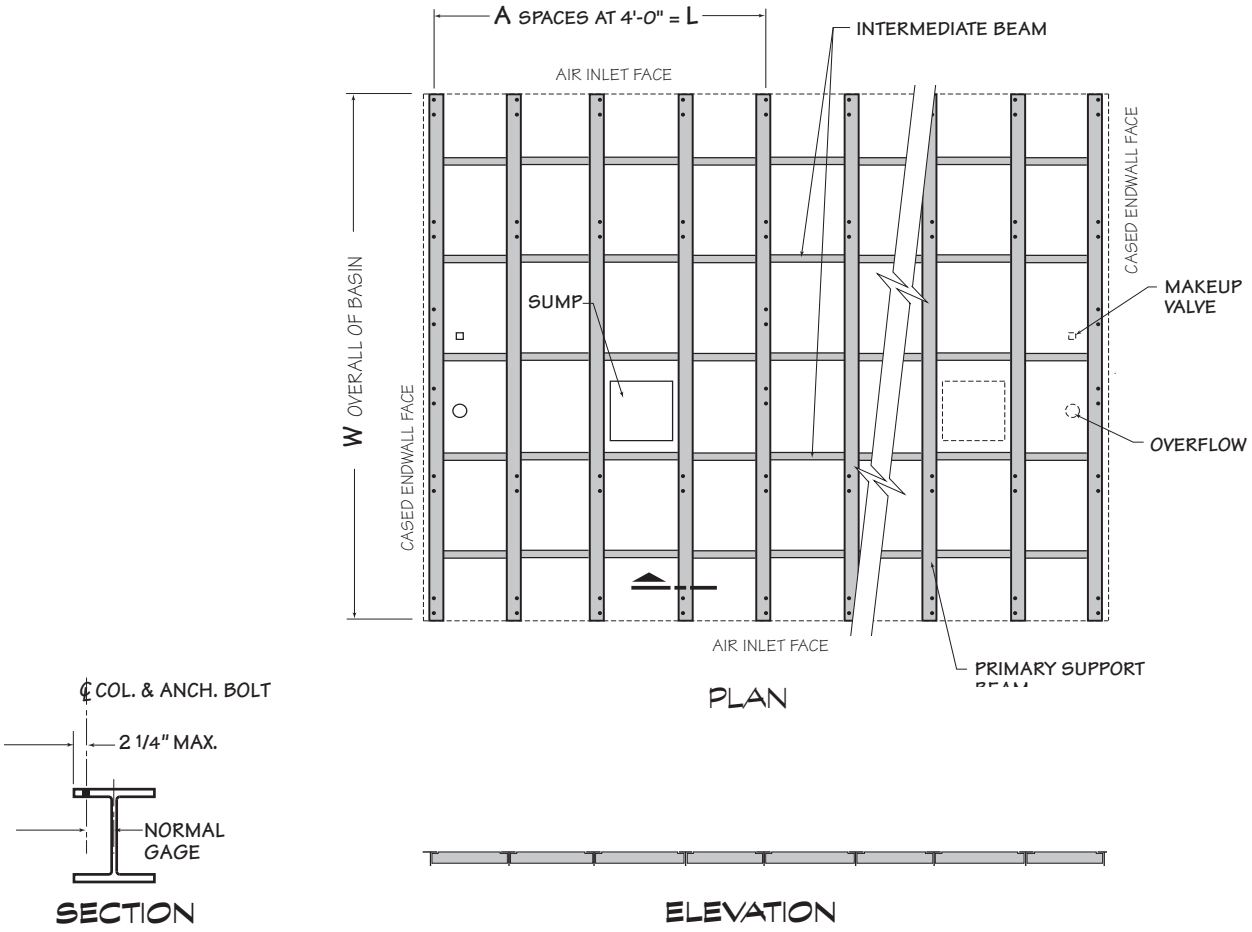


ENDWALL ELAVATION

Tower Model	Dimensions					
	W	L	H	A	B	C
F1211	29'-2"	16'-0"	19'-6"	4	6'-0"	144"
F1221	31'-2"	16'-0"	20'-6"	4	7'-0"	168"
F1231	31'-2"	20'-0"	20'-6"	5	7'-0"	168"
F1241	31'-2"	24'-0"	20'-6"	6	7'-0"	168"
F1251	35'-2"	24'-0"	20'-6"	6	7'-0"	216"
F1261	35'-2"	28'-0"	20'-6"	7	7'-0"	216"

NOTE

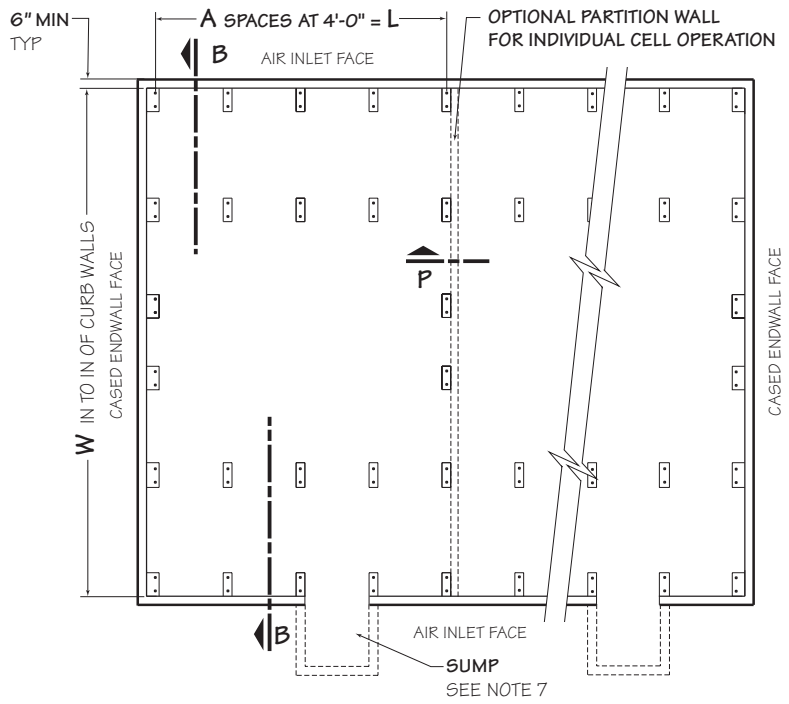
1 U*se this bulletin for preliminary layouts only.* Obtain current drawings from your Marley representative.
2 All table data is per cell.
3 All tower installations require a minimum of 4'-0" from centerline of tower endwall column to any vertical obstruction at tower ladder location. Ladder can be located at any corner of the fan deck. Ladder extends 8⅜" below the base of tower columns on applications with a stainless steel cold water basin. Ladder stops at top of basin curb wall on applications with a concrete basin.
Tower installations with an elevation 20'-0" or more from the top of the fan deck to grade or roof level require a safety cage on the tower ladder in compliance with OSHA standards. Marley ladder safety cages are available as an option.



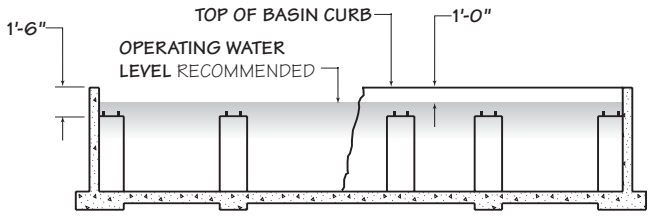
Tower Model Note 4	Dimensions			Operating Weight lb	
	A	W	L	Single Fan Cell	Each Cell Add
F1211	4	26'-6"	16'-0"	55810	51510
F1221	4	28'-6"	16'-0"	59300	54920
F1231	5	28'-6"	20'-0"	70180	65760
F1241	6	28'-6"	24'-0"	81410	77020
F1251	6	32'-6"	24'-0"	91070	86450
F1261	7	32'-6"	28'-0"	102800	98090

NOTE

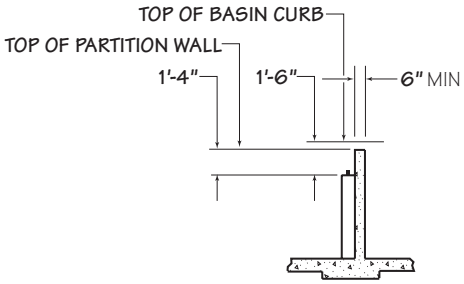
1 *Use this bulletin for preliminary layouts only.* Do not use for construction. Obtain current drawings from your Marley representative.
2 Operating weight is total wet weight including stainless steel collection basin with 6" (recommended operating water level) of water.
3 Purchaser to design, construct and furnish supporting steel complete with 13⁄16" diameter holes for anchor bolts to suit the general dimensions of current Marley drawings.
4 Last number of model indicates number of cells. Change as appropriate for your selection. Primary engineering data is per cell.
5 Maintain no less than 2'-0" of clear space at tower endwalls for construction purposes. Louvered faces must have unobstructed air supply. If obstructions exist nearby, consult your Marley representative.



PLAN



SECTION B

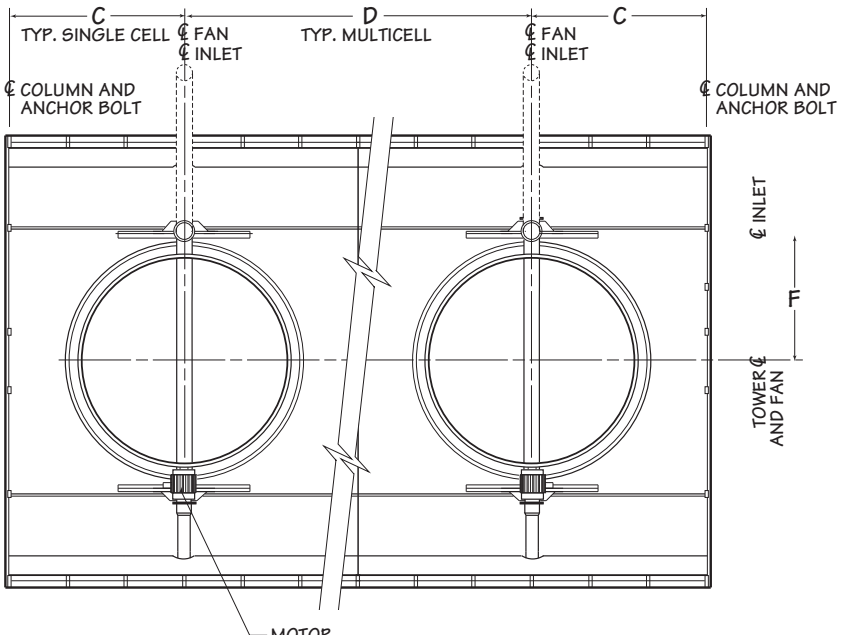


SECTION P

Tower Model Note 4	Dimensions			Operating Weight lb	
	A	W	L	Single Fan Cell	Each Cell Add
F1211	4	26'-4"	16'-0"	39220	35920
F1221	4	28'-4"	16'-0"	41460	38160
F1231	5	28'-4"	20'-0"	48200	44860
F1241	6	28'-4"	24'-0"	55300	51980
F1251	6	32'-4"	24'-0"	61260	57880
F1261	7	32'-4"	28'-0"	68280	64800

NOTE

1 *Use this bulletin for preliminary layouts only.* Do not use for construction. Obtain current drawings from your Marley representative.
2 Tower weight is total wet operating weight of tower only excluding water in the concrete basin.
3 Purchaser to design, construct and furnish concrete basin complete to suit the general dimensions of current Marley drawings.
4 Last number of model indicates number of cells. Change as appropriate for your selection. Primary engineering data is per cell.
5 All anchor bolts complete with nut and washer will be furnished by others. Bolts are ¾" diameter with 1½" all thread projection. Material should be stainless steel.
6 Maintain no less than 2'-0" of clear space at tower endwalls for construction purposes. Louvered faces must have unobstructed air supply. If obstructions exist nearby, consult your Marley representative.
7 Purchaser must design, construct, and furnish sump(s) and overflow(s) to suit requirements. The sump should be designed according to the pump manufacturer's recommendations.



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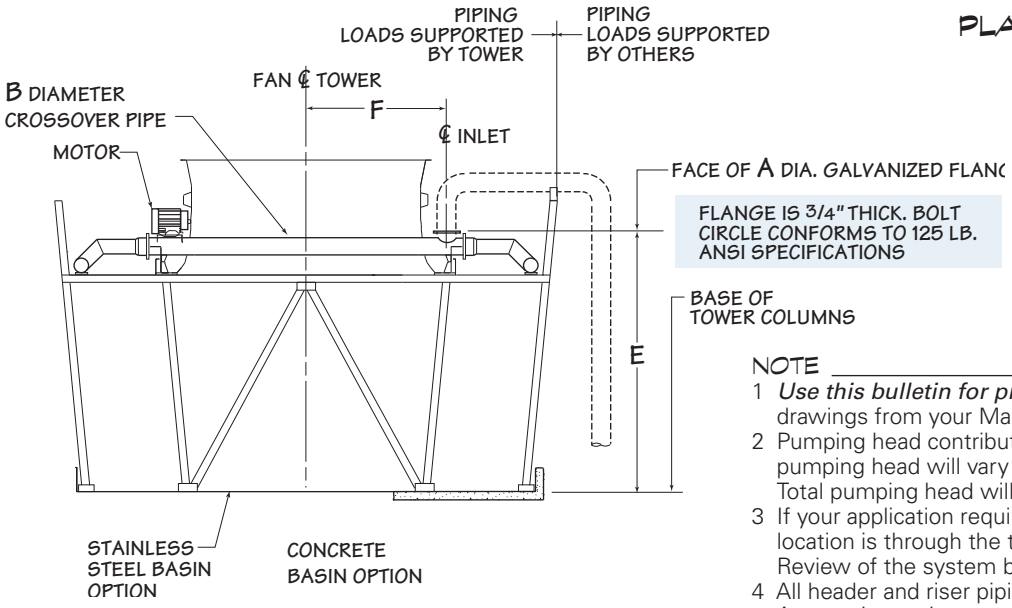
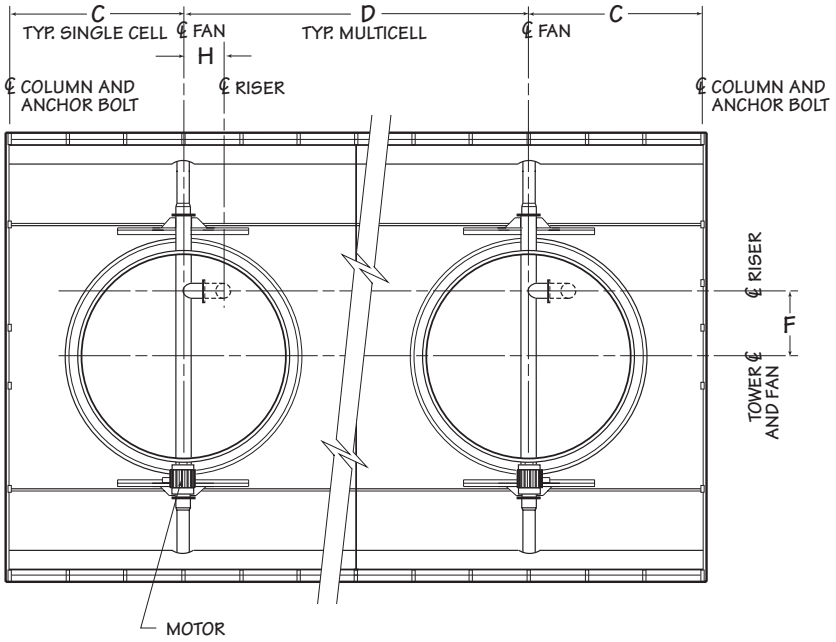


END ELEVATION

NOTE

1 *Use this bulletin for preliminary layouts only.* Obtain current drawings from your Marley representative.
2 Pumping head contributed by the tower is static lift E. Actual pumping head will vary according to tower circulating GPM. Total pumping head will be furnished at time of proposal.
3 If your application requires a bypass system, recommended location is through the tower endwall into the plenum area. Review of the system by SPX engineering is required.
4 All header and riser piping to be furnished by others. A corrosion-resistant material or coating for piping is recommended. All inlet piping loads, including thrust and seismic, outside of tower plan area must be supported by others.

Tower Model	Flow/Cell GPM	Dimensions					
		A	B	C	D	E	F
F1210	1050-5750	12"	10"	8'-0"	16'-0"	15'-10⅞"	7'-6"
F1220	1050-5750	14"	12"	8'-0"	16'-0"	15'-11⅞"	8'-6"
F1230	1320-7200	14"	12"	10'-0"	20'-0"	15'-11⅞"	8'-6"
F1240	1500-8650	14"	12"	12'-0"	24'-0"	15'-11⅞"	8'-6"
F1250	1500-8650	16"	14"	12'-0"	24'-0"	16'-0⅞"	10'-6"
F1260	1850-10100	16"	14"	14'-0"	28'-0"	16'-0⅞"	10'-6"



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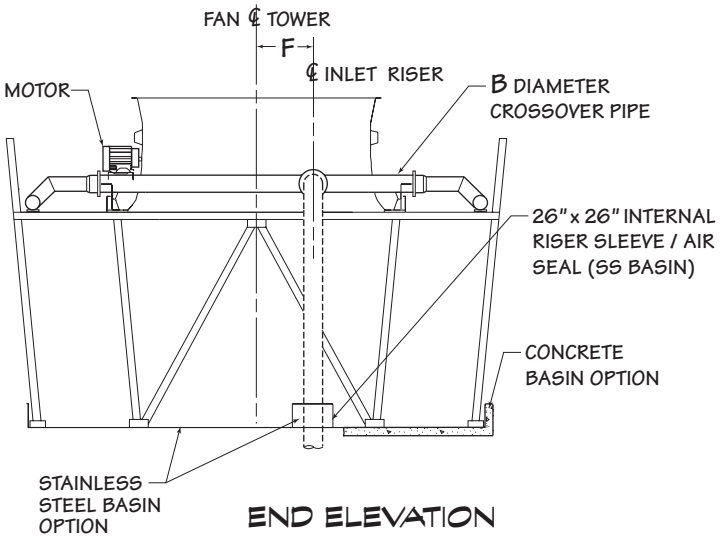
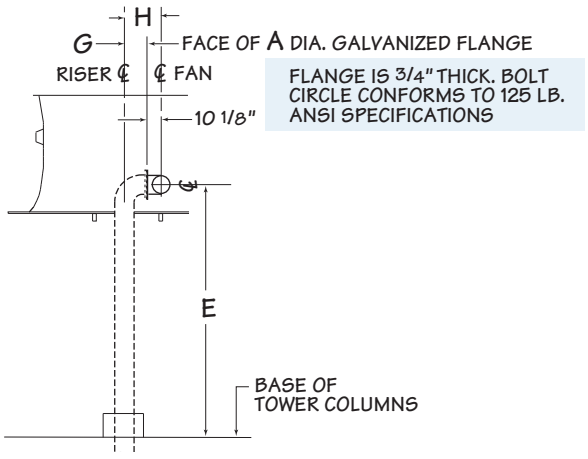
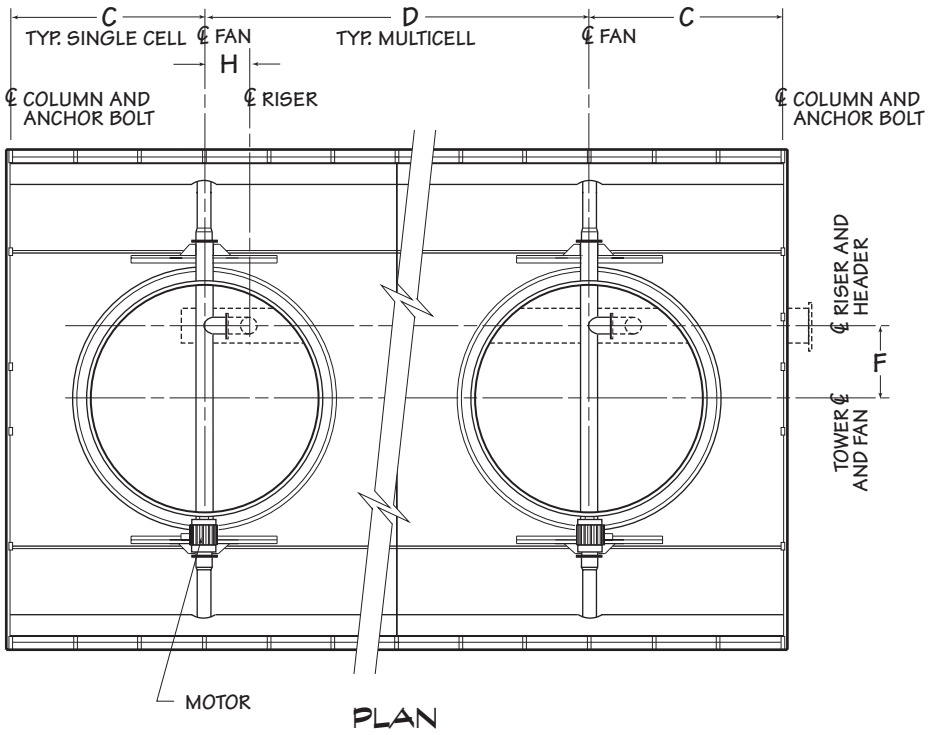


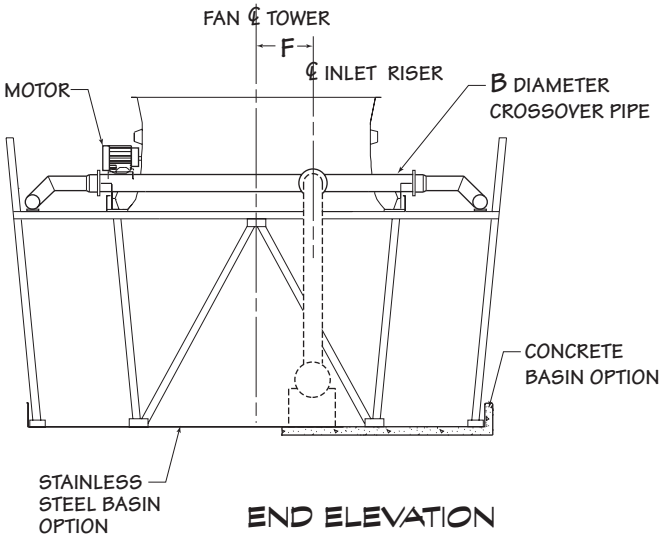
END ELEVATION

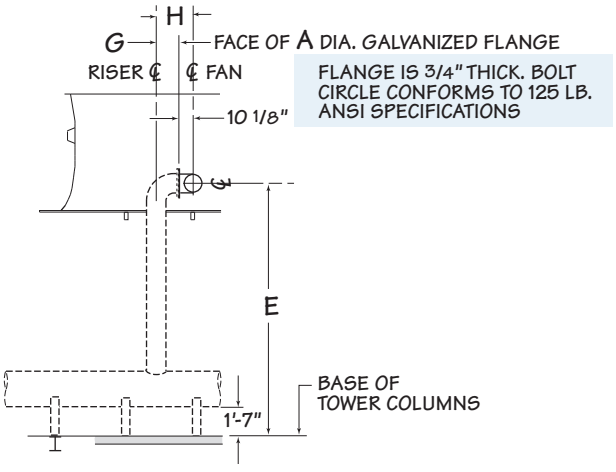


SIDE ELEVATION

Tower Model	Flow/Cell GPM	Dimensions							
		A	B	C	D	E	F	G	H
F1210	1050-5750	12"	10"	8'-0"	16'-0"	15'-0¾"	3'-3"	1'-7⅞"	2'-6"
F1220	1050-5750	14"	12"	8'-0"	16'-0"	15'-1¾"	3'-6"	1'-7⅞"	2'-6"
F1230	1320-7200	14"	12"	10'-0"	20'-0"	15'-1¾"	3'-6"	2'-7⅞"	3'-6"
F1240	1500-8650	14"	12"	12'-0"	24'-0"	15'-1¾"	3'-6"	1'-7⅞"	2'-6"
F1250	1500-8650	16"	14"	12'-0"	24'-0"	15'-2¾"	3'-9"	1'-7⅞"	2'-6"
F1260	1850-10100	16"	14"	14'-0"	28'-0"	15'2¾"	3'-9"	3'-1⅞"	3'-9"







NOTE

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2 Pumping head contributed by the tower is static lift E. Actual pumping head will vary according to tower circulating GPM. Total pumping head will be furnished at time of proposal.
3 If your application requires a bypass system, recommended location is through the tower endwall into the plenum area. Review of the system by SPX engineering is required.
4 All header and riser piping to be furnished by others. A corrosion-resistant material or coating for piping is recommended. Do not support riser dead load or operating load from inlet connection or tower structure.

Cooling towers are usually selected to produce a specific cold water temperature at the higher summertime wet-bulb temperatures. During the remainder of the year, the cooling tower is capable of producing much colder water. Unless your system will benefit from the coldest possible water temperature, you should consider controlling cold water temperatures to higher levels. You'll also save energy by using such control. For greater insight on cold water temperature control, please read "**Cooling Tower Energy and its Management**", *Technical Report #H-001A*, available from your Marley sales representative or on the web at spxcooling.com.

Always control leaving water temperature by manipulating the quantity of air that the fan moves through the tower. Varying the quantity of water flow is not normally recommended and can be harmful in freezing weather. You can alternately start and stop single-speed motors to maintain water temperatures within an acceptable range. However, exceeding a total acceleration time of 30 seconds per hour can overheat the motor, causing the insulation to fail. Limiting the number of motor starts, on the other hand, can produce significant variations in the temperature of the water delivered to the process.

Increased flexibility can simplify your operating procedures and save you money in the long run, both on operation and on maintenance. Here are two of the more popular options.

Two-Speed Motors

Two-speed motors improve operating flexibility by increasing the number of potential operating modes. Users in northern climates will find that the tower can carry winter loads at half-speed; reducing fan power requirements by 85+% during that time. Two-speed motors also help to control icing during wintertime operation. See Marley *Technical Report #H-003*, "Operating Cooling Towers During Freezing Weather," available from your Marley sales representative or on the web at spxcooling.com.

Normally, two-speed motors are provided in 1800/900 RPM, single winding configuration, which is the least expensive two-speed option. They are also available in other combinations including the more expensive double winding.

Variable Speed Fan

Frequency modulation devices work well on induced draft, propeller fan cooling towers such as the Sigma. However, their design must include the capability to lock out any critical fan speeds and the very low fan speed ranges.

Marley VFD drive systems are designed to combine absolute temperature control with ideal energy management. The cooling tower user selects a cold water temperature and the drive system will vary the fan speed to maintain that temperature. Precise temperature control is accomplished with far less stress to the mechanical equipment components. The improved energy management provides fast payback. Indeed, many utilities offer generous rebates for users having installed VFD drives.

⚠ CAUTION

The cooling tower must be located at such distance and direction to avoid the possibility of contaminated tower discharge air being drawn into building fresh air intake ducts. The purchaser should obtain the services of a Licensed Professional Engineer or Registered Architect to certify that the location of the tower is in compliance with applicable air pollution, fire, and clean air codes.

Sound Control

Sound produced by a Sigma tower operating in an unobstructed environment will meet all but the most restrictive noise limitations—and will react favorably to natural attenuation. Where the tower has been sized to operate within an enclosure, the enclosure itself will have a damping effect on sound. Sound also declines with distance—by about 5 dBA each time the distance doubles. Where noise at a critical point is likely to exceed an acceptable limit, several options are available—listed below in ascending order of cost impact:

- In many cases, noise concerns are limited to nighttime, when ambient noise levels are lower and neighbors are trying to sleep. You can usually resolve these situations by using two-speed motors in either 1800/900 or 1800/1200 RPM configuration—operating the fans at reduced speed without cycling "after hours". The natural nighttime reduction in wet-bulb temperature makes this a very feasible solution in most areas of the world, but the need to avoid cycling may cause the cold water temperature to vary significantly.

- The Marley Variable Frequency Drive automatically minimizes the tower's noise level during periods of reduced load and/or reduced ambient temperature without sacrificing the system's ability to maintain a constant cold water temperature. This is a relatively inexpensive solution, and can pay for itself quickly in reduced energy costs.

- Where noise is a concern at all times—for example, near a hospital—the best solution is to oversize the tower so it can operate continuously at reduced (1200 or 900 RPM) motor speed. Typical sound reductions are 7 dBA at ⅔" fan speed or 10 dBA at ½" fan speed.

- Extreme cases may require inlet and discharge sound attenuator sections—however, the static pressure loss imposed by attenuators may necessitate an increase in tower size. This is the least desirable approach because of the significant cost impact—and because of the obstruction to normal maintenance procedures.

Your Marley representative will help you meet your sound requirements.

Enclosures

Occasionally, cooling towers are located inside architectural enclosures for aesthetic reasons. Although Sigma towers adapt well to enclosures, the designer must realize the potential impact of a poorly arranged enclosure on the tower's performance and operation. The designer must take care to provide generous air inlet paths, and the tower's fan cylinder discharge height should not be lower than the elevation of the top of the enclosure. Obtain a copy of Marley *Technical Report #H-004*, "External Influences on Cooling Tower Performance" from your Marley sales representative or on the web at spxcooling.com..

As suggested in the aforementioned Technical Report, it may also be advisable to specify a design wet-bulb temperature 1°F higher than normal to compensate for potential recirculation initiated by the enclosure. You'll benefit from discussing your project with your Marley representative.

Keeping It Clean

Cooling towers are very effective air washers. Atmospheric dust able to pass through the relatively small louver openings will enter the circulating water system. Increased concentrations can intensify system maintenance by clogging screens and strainers—and smaller particulates can coat system heat transfer surfaces. In areas of low flow velocity—such as the cold water basin—sedimentary deposits can provide a breeding ground for bacteria.

In areas prone to dust and sedimentation, you should consider installing some means for keeping the cold water basin clean. Typical devices include side stream filters and a variety of filtration media.

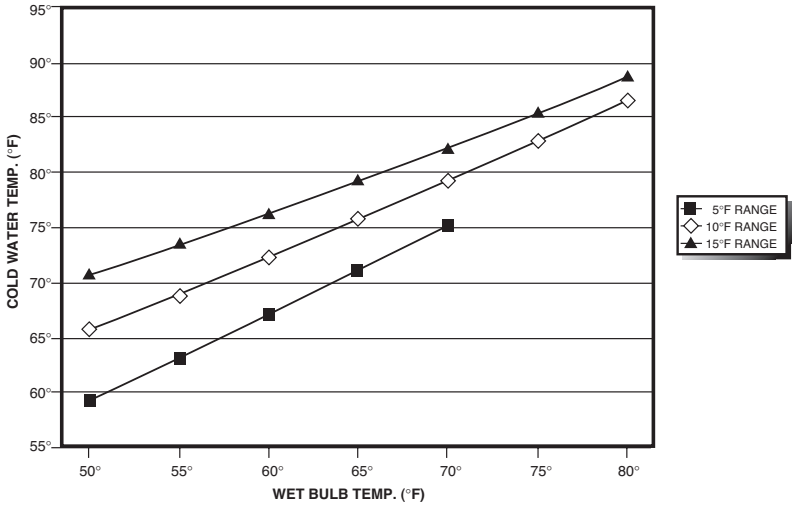
Water Treatment

To control the buildup of dissolved solids resulting from water evaporation, as well as airborne impurities and biological contaminants including Legionella, an effective consistent water treatment program is required. Simple blowdown may be adequate to control corrosion and scale, but biological contamination can only be controlled with biocides.

An acceptable water treatment program must be compatible with the variety of materials incorporated in a cooling tower—ideally the pH of the circulating water should fall between 6.5 and 8.0. Batch feeding of chemicals directly into the cooling tower is not a good practice since localized damage to the tower is possible. Specific startup instructions and additional water quality recommendations can be found in the Sigma User Manual which accompanies the tower and also is available from your local Marley sales representative. For complete water treatment recommendations and services, contact your local Marley sales representative.

Specifications	Specification Value
1.0 **Base:**	
1.1 Furnish and install an induced-draft, crossflow-type, field-erected, structural fiberglass-framed, PVC film-fill, industrial-duty cooling tower of _____ cell(s), as shown on Plans. The limiting overall dimensions of the tower shall be _____ wide, _____ long, and _____ high to the top of the fan cylinder. Total operating horsepower of all fans shall not exceed ____ hp, driven by ___ @ _____ hp motor(s). Pump head, including static lift above top of cold water basin curb (or top of supporting steel), shall not exceed ____ feet of water. Tower shall be similar and equal in all respects to Marley Sigma F Series, Model _____.	■ Your specification base establishes the type, configuration, base material, and physical limitations of the cooling tower to be quoted. During the planning and layout stages of your project, you will have focused your attention on a cooling tower selection that fits your space allotment, and whose power usage is acceptable. Limitations on physical size and total operating horsepower avoid the introduction of unforeseen operational and site-related influences. Specifying the number of cells, and the maximum fan hp/cell will work to your advantage. Your reason for specifying a crossflow type is that crossflow towers are noted for the accessibility and maintainability of all operating components. The spacious interior provides easy access to fill, drift eliminators, all basin accessories—and is one of two primary accessways to the fan, Geareducer, and other mechanical components. At the fan deck level, the hot water distribution basins are easily inspected and cleaned—while the tower is operating, if necessary. The mechanical equipment can also be readily accessed from this level. Except for the cold water basin, no counterflow tower component requiring routine maintenance is as easily accessed. The confined areas that typify counterflow designs, particularly of forced draft configuration can make difficult work for maintenance personnel!

Specifications	Specification Value
2.0 **Thermal Performance:**	
2.1 The tower shall be capable of cooling _____ GPM of water from ____ °F to _____ °F at a design entering air wet-bulb temperature of _____ °F. The cooling tower manufacturer shall guarantee that the tower supplied will meet the specified performance conditions when the tower is installed according to plans.	■ Your reason for purchasing a cooling tower is to obtain a continuing flow of cooled water as defined in the first paragraph at left. If the tower that you purchase is incapable of performing as specified, then you will not have received full value for your money. Bear in mind that the size—and cost—of a cooling tower varies directly with its true thermal capability. This paragraph is intended to protect you against either intentional or inadvertent undersizing of the tower by the manufacturer. Judging the level of performance of a cooling tower on critical processes is never easy, and the potential risk of a non-performing cooling tower usually causes the requirement for a mandatory acceptance test to be very desirable.
2.2 The purchaser will arrange for an on-site thermal performance test, to be conducted in the presence of the manufacturer and owner, and under the supervision of a qualified, disinterested third party in accordance with CTI (Cooling Technologies Institute) ATC-105 standards during the first full year of operation. If the tower fails to perform within the limits of test tolerance, then the cooling tower manufacturer will install additional cells and/or make such corrections as are agreeable to the owner and shall pay for the cost of a retest. If the tower still fails to perform as specified, then the manufacturer shall make such reimbursements as are appropriate and agreeable to the owner to compensate for the performance deficiency.	Your contract with the successful bidder should establish the acceptable remedies for missed performance, which might include: • The addition of one or more cells of tower, as necessary, to bring the cooling tower to the specified level of performance. This is usually limited to the scope of work as defined in the specs, which means that you (the owner) will have to pay for the additional basin, wiring, starters, piping, etc. • The reimbursement of a portion of the total contract price equal to the percentage deficiency in performance. *Under no circumstances should you allow the manufacturer to repitch the fans to increase motor brake horsepower above that shown in the proposal. That creates additional operating costs that will continue for the life of the tower—and imposes no penalty on the manufacturer.*



Typical cooling tower performance curve.

Specifications	Specification Value
3.0 **Construction:**	
3.1 The tower shall be capable of withstanding water having a pH of 6.5 to 8.0; a chloride content (NaCl) up to 750 ppm; a sulfate content (SO_4) up to 1200 ppm; a calcium content ($CaCO_3$) up to 800 ppm; silica (SiO_2) up to 150 ppm; and design hot water temperatures up to 120°F (48.9°C). The circulating water will contain no oil, grease, fatty acids, or organic solvents.	■ The limiting water quality values indicated are those which are acceptable for the normal materials of construction specified. If water of more aggressive quality is anticipated please change hardware material requirement to series 316 stainless steel, or silicon bronze, as you may have agreed upon beforehand with the Marley sales representative. If there is any doubt in your mind as to the grade of hardware that is appropriate to your water quality, please have a sample of it analyzed and provide Marley with a copy of the analysis.
3.2 The structural framework of the tower shall be pultruded or molded fiberglass, designed in accordance with ASCE Structural Plastics Design Manual. All allowable design values shall be factored for wet service, temperature, and duration in accordance with standard engineering practices.	
3.3 Basic design criteria shall be 30 psf (1.44 kPa) wind load and 5%g seismic load.	Discuss higher design loadings with your Marley sales representative.
3.4 Multicell towers shall include stainless steel partitions between cells in the fill areas, and fiberglass partitions in the plenum area. Partitions shall extend the full height of the tower from the base of fill to the underneath side of the fan deck.	Multicell towers must have plenum partitions between cells. Otherwise, air will be induced downward through an inoperative fan, bypassing the fill entirely. Without these partitions, part-load or off-season operation of the tower would be completely unsatisfactory. Fill partitions prevent the random migration of water from cell to cell, and permit individual cell operation during reduced ambient or low load conditions.
3.5 Column lines shall be on no greater than 4'-0" (1.22 m) longitudinal centers, and the base of all columns shall be firmly anchored to series 304 stainless steel base plates. Framing joints shall be made with 1/2" diameter or larger series 300 stainless steel machine bolts. Critical framing joints shall be augmented with 1.06" OD heavy wall fiberglass sleeves to transmit loads.	
3.6 No field gluing of joints, or any other structural member, will be allowed.	The variable weather conditions encountered during on-site construction of cooling towers does not result in the stable conditions of temperature and humidity that assure proper bonding during the gluing process.

Specifications	Specification Value
4.0 **Fan Deck and Fan Cylinder:**	
4.1 The fan deck shall act as a working platform for maintenance personnel. It shall consist of 1 1/8" (28.5 mm) deep pultruded fiberglass interlocking panels, supported by structural fiberglass joists on 3'-0" (914 mm) maximum centers. Fan deck shall have a nonskid surface. Deck shall be designed for a uniform live load of 60 psf (2.9 kPa) or a concentrated load of 400 pounds (181 kg). Mid-span deflection at 60 psf (2.9 kPa) loading shall not exceed 0.17" (4.3 mm).	■ The indicated design values for framing and decking not only give you assurance that the tower can withstand long term operation in a hostile environment—but that it will accept many years of inspection and maintenance traffic by your operating personnel.
4.2 Fan cylinders shall be molded FRP. They shall be anchored to the fan deck structure to provide a consistently stable operating shroud for the fan.	Fiberglass-reinforced polyester fan cylinders provide the close tip clearances and smooth airflow contour necessary for good fan performance. The inert, noncorroding nature of FRP assures that these characteristics will persist.
5.0 **Mechanical Equipment:**	
5.1 Fan(s) shall be propeller-type, incorporating heavy duty blades of high strength, inert fiberglass reinforced epoxy material. Blades shall be individually adjustable and replaceable. Fan(s) shall be driven through a right angle, industrial-duty, oil-lubricated, geared speed reducer. Speed reducers employing pulleys and belts will not be accepted.	■ Standard fan drives of other manufacturers may use V-belts. Considering the size of fans involved—and the horsepower applied—this is not good design practice. Geareducer drive is far more reliable and trouble free, and is currently offered as an option by most other cooling tower manufacturers. The primary means of capacity control on cooling towers is by cycling fans on and off, or through a variety of speed changes. Such cycling can stretch V-belts, and can reduce their service life significantly.
5.2 Motor(s) shall be ____ hp maximum, TEFC, 1.15 service factor, and specially insulated for cooling tower duty. Speed and electrical characteristics shall be 1800 (1800/900) RPM, single winding, ___ phase, ___ hertz, ___ volts.	Unless otherwise specified, motor speed will be 1800 RPM in 60 Hertz areas and 1500 RPM in 50 Hertz areas. If you prefer the operating flexibility of two-speed operation, please specify the RPM to be 1800/900 (1500/750 in 50 Hertz regions). Other speed ranges are also available,
5.3 Motor shall be located outside the fan cylinder at the fan deck, and shall be connected to the speed reducer by a tubular stainless steel, dynamically balanced driveshaft with heavy galvanized yokes and neoprene flexible coupling elements.	The driveshaft turns at the motor speed and is, therefore, most sensitive to operational imbalance. Stainless steel manufacture assures that the driveshaft will not become unbalanced as a result of corrosion. Stainless steel yokes are available at extra cost, although not normally necessary.

Specifications	Specification Value
5.4 A stainless steel oil fill and drain line shall extend from the gear reducer to the vicinity of the motor, and shall be equipped with a bronze-bodied oil level sight-glass gauge.	The extended oil line to an oil gauge provides a safe and convenient means of checking the level of oil in the Geareducer.
5.5 The complete mechanical equipment assembly for each cell shall be supported by a rigid, unitized support that resists misalignment between the motor and the gear reducer. Support shall be heavy-wall tubular steel, to which heavy plate platforms for the motor and gear reducer have been welded and the assembly shall be hot-dip galvanized after fabrication. The support assembly shall also provide an inlet connection for incoming hot water, and shall serve as a crossover pipe to deliver water to both sides of the tower.	Fans of the size used on large cooling towers are applied at speeds and horsepowers that generate considerable torque—and structural tubular steel resists this torque very effectively. The Marley torque-tube design assures that all of the mechanical equipment remains aligned, and that the rotating fan is properly positioned within the fan cylinder. Hot-dip galvanizing after fabrication assures that all steel surfaces will be heavily coated with zinc for long-term protection against corrosion. Even in aggressive water conditions, the heavy construction of the unitized support normally precludes the need for stainless steel. It is available, however, at extra cost.
5.6 The mechanical equipment assembly shall be warranted for no less than five (5) years. This warranty shall cover the fan(s), speed reducer(s), driveshaft(s), couplings, and the unitized supports.	The value of a 5 year mechanical equipment warranty speaks for itself. Except for the motor, all of the mechanical equipment on a Marley tower is made by Marley. Cooling tower vendors who purchase commercial fans, gear boxes, driveshafts, etc. may require that you deal directly with those commercial suppliers for warranty satisfaction.
6.0 **Fill, Louvers and Drift Eliminators**:	
6.1 Fill shall be film-type, 15 mil (0.38 mm) thick, thermoformed PVC, with louvers formed as part of each fill sheet. Fill shall be suspended from stainless steel structural tubing supported from the upper tower structure, and shall be elevated above the floor of the cold water basin to facilitate cleaning. Air inlet faces of the tower shall be free of water splashout.	■ Louvers integral with the fill keep the flowing water within the confines of the fill. The separate external louvers used by others permit water to escape the fill and form ice or produce an unsightly situation adjacent to the tower. If you plan to use your tower in the wintertime, particularly for free cooling, integral louvers will put your operating concerns to rest.
6.2 Drift eliminators shall be 15 mil (0.38 mm) thick PVC, formed as part of each fill sheet, triple-pass, cellular type, and shall limit drift losses to 0.005% or less of the design water flow rate. The final pass of the eliminators shall direct the air toward the fan.	Vertical blade-type eliminators, as well as misdirected cellular types, cause much of the fan power to be wasted in turning the horizontal flow of air vertical for its exit through the fan cylinder. This power is, of course, not available for contribution to thermal performance. Drift rate varies with design water loading and air rate, as well as drift eliminator depth and number of directional changes. A drift rate of 0.001% is readily available in standard configuration without premium cost. If a lower rate is required, please discuss with your Marley sales representative.

Specifications	Specification Value
7.0 **Hot Water Distribution System:**	
7.1 The mechanical equipment support/ crossover pipe for each cell shall be equipped with a flange for the attachment of customer supply piping. Inlet and bolt circle dimensions shall conform to 125# flange specifications. The crossover pipe shall deliver water through PVC perforated pipes to two open, stainless steel, hot water basins at the fan deck elevation. Water shall exit these basins to the fill by gravity through metering orifice type polypropylene nozzles situated in the basin floor. Nozzles shall be easily removable and replaceable.	■ Gravity-flow distribution basins are a feature of crossflow type towers. These basins are out where they can be easily inspected—even cleaned—while the tower is in operation. Spray systems of counterflow towers, being sandwiched between the top of the fill and the drift eliminators, are extremely awkward to access and maintain, and require the system to be shut down for cleaning.
7.2 Water inlet system shall be self-balancing, requiring no special valving for flow regulation from side-to-side of tower.	The Sigma F Series is designed such that the supply piping to the tower will not appear outside the tower. Not only does this enhance the tower's architectural appearance, but it also aids the self-balancing aspect of the Sigma F Series water distribution system.
7.3 Water distribution system design shall allow water flow reductions down to 50% of design flow without modifications or adjustments.	This feature of the Sigma F Series tower allows you to vary the water circulation rate as an added means of controlling tower performance capacity during reduced-load or off-season operation.
8.0 **Casing:**	
8.1 The endwalls of the tower, as well as the sidewalls above the air inlet elevation to the top of the distribution basin, shall be cased with 12 oz/sq ft horizontally corrugated FRP panels attached to tower columns with stainless steel self-tapping fasteners and self-sealing washers. Panels shall be lapped to shed water inward to the tower. Vertical joints shall be lapped and sealed watertight. Casing ends at tower corners shall be covered with pultruded FRP angles.	■ 8 oz casing panels are also available at reduced cost, but the sturdier 12 oz panels are strongly recommended. Also, if fire-retardant casing is preferred, it would be appropriate to add the following sentence to the end of paragraph 8.1 at left: "Casing panels shall have a flame spread rating of 25 or less." Heavy duty architectural casing panels are also available, as described on page 23. Architectural treatment can also be enhanced by extending the casing up to the top of the fan deck guardrail. This is described on page 23.
8.2 In the water-washed endwall fill areas, inner casings of 16 gauge 304 stainless steel shall also be provided.	

Specifications	Specification Value
9.0 **Access and Safety:**	
9.1 Single cell towers shall include a 33" (838 mm) wide by 61" (1.55 m) high molded FRP access door in one endwall casing for access to the interior of the tower. Casing access door shall be hinged and equipped with a latch operable from both inside and outside the tower. Multicell towers shall have an access door in both endwalls, and shall include a hinged door in each transverse partition to give free access through the tower.	■ The access doors on other towers may be unreasonably small. Specifying the size of the door will cause those bidders to take exception, alerting you to a potential maintenance headache. Good maintenance practice requires periodic access to the top of the tower to inspect the distribution basins, as well as the structural integrity of the fan deck, fan cylinder, and fan—especially the fan blade securing hardware. And there are no induced-draft cooling tower designs that are immune to this need! Please beware of those manufacturers who suggest otherwise.
9.2 The top of the tower shall be equipped with a sturdy 42" (1067 mm) high fiberglass guardrail system, complete with top rails, intermediate rails, and toeboards conforming to OSHA standards. Guardrail posts shall be extensions of the tower columns.	For the comfort and safety of your operating personnel, the Sigma F Series includes a ladder and guardrail of the quality and design indicated—and we strongly recommend that you require it of all bidders! Portable ladders and other "make-do" access means are inappropriate for equipment of this size and complexity.
9.3 One endwall of the tower shall be equipped with a 20" (508 mm) wide aluminum vertical ladder, supported by hot-dip galvanized steel brackets through-bolted to the endwall structure. Ladder shall rise from the cold water basin level to the top of the fan deck guardrail, and shall be designed and installed in conformance with OSHA standards. A horizontal-swing, gravity-closing safety bar shall be provided across the ladder opening at the fan deck.	
10.0 **Cold Water Basin:**	
10.1 A large galvanized, rectangular access door shall be located on both end panels for entry into the cold water basin. Rectangular panels are shall be provided for access to the fan plenum area to facilitate inspection and allow maintenance to the fan drive system	■ This basic specification assumes that the tower will be erected over a concrete basin at grade level. If the tower is to be installed on an elevated supporting platform, the stainless steel cold water collection basin indicated on page 20 should be included in the specifications.
10.2 Concrete partitions, if required between cells in the cold water basin, shall be installed in accordance with manufacturer's drawings. Tower installer shall seal between tower cell partitions and basin cell partitions.	

Specifications	Specification Value
11.0 **Scope of Work**:	
11.1 The cooling tower manufacturer shall be responsible for the design, fabrication, and delivery of materials to the project site, and for the erection of the tower over supports provided by others. Unless otherwise specified, all supply and return piping, pumps, controls, and electrical wiring will be outside the cooling tower manufacturer's scope of work.	■ Please be clear in your specifications and inquiry documents regarding the full scope of work expected. That will help assure that your bid comparisons will be made on as equal a basis as possible—and will help to avoid any misunderstandings during the execution and implementation of the contract.

Specifications	Specification Value
Cold Water Basin Options	
Stainless Steel Cold Water Basin:	■ Marley basins are used to permit the installation of towers on elevated platforms or foundations. This is the simplest of several cold water basin designs available for the Sigma F Series towers. If preferred, a 10 gauge welded stainless steel basin can be installed.
10.1 *Replace paragraph 10.1 with the following:* Include a cold water collection basin constructed of 12 gauge series 304 stainless steel, through-bolted and sealed to prevent leakage. A depressed, side outlet sump of series 304 stainless steel having a ¼" (6.4 mm) thick faceplate drilled for a standard class 125# ASME flange connection will be included. A removable stainless steel ½" mesh debris screen shall cover the top of the sump. An appropriately sized (4" diameter or larger) stainless steel standpipe overflow shall be provided. The standpipe shall be removable for flush-out cleaning of the basin. A float-operated, mechanical makeup valve shall also be included, installed adjacent to the endwall access door.	
Watertight Partition between Tower Cells with Stainless Steel Cold Water Basin Option:	■ In addition to the normal partition function of preventing air bypass (page 14), this option allows you to use each partitioned cell of your tower independently. This is valuable where a single multicell tower is serving several separate systems—or where winter operation may require less than full tower capability.
10.2 *Replace paragraph 10.2 with the following:* Stainless steel watertight partitions shall be provided between cells in the cold water basin. They shall be sealed watertight to the partitions in the fill and plenum areas of the tower. Cold water basin partitions shall have weir openings allowing free flow of water between cells. Weirs shall be equipped with bolt-on, gasketed cover plates to prevent water passage when required.	
Basin Heater:	■ The basin heater components described at left represent is recommended for a reliable automatic system for the prevention of basin freezing. The ambient air temperature that you fill in should be the lowest 1% level of winter temperature prevalent at site.
10.3 *Add the following paragraph in the Cold Water Basin section:* Add the following paragraph in the Cold Water Basin section: Provide a system of electric immersion heaters and controls to prevent freezing of water in the collection basin during periods of shutdown. The system shall consist of one or more stainless steel electric immersion heaters. A NEMA 4 enclosure shall house a magnetic contactor to energize heaters; a transformer to provide 24 volt control circuit power;	

Specifications	Specification Value
and a solid state circuit board for temperature control and low water cutoff. A control probe shall be located in the basin to monitor water level and temperature. The system shall be capable of maintaining 40°F water temperature at an ambient air temperature of ____ °F. Wiring of the heaters and the heater components shall be the responsibility of the purchaser.	
Convenience and Safety Options	
Fiberglass Stairway:	
9.3 *Replace paragraph 9.3 with the following:* One endwall of the tower shall be equipped with a structural fiberglass stairway rising from grade (roof) to the fan deck. Treads, stringers and risers shall be molded integrally for strength and stiffness. Stairs shall be 41.5°, 30" (762 mm) wide, with 8" (203 mm) rise and 9" (229 mm) run. Treads shall have a nonskid surface. Landings shall occur at 6'-0" (1.83 m) elevations. Guardrails shall be 2" tubes, through-bolted to 3" tube stairway columns. Stairway foundation shall be by others, designed in accordance with drawings provided by the cooling tower manufacturer. The stairway shall conform to OSHA standards.	■ Although they are not necessary for routine operation and maintenance, stairways do provide a safe and comfortable means of access to the top of the tower that is often overlooked in the initial cooling tower purchase. And fiberglass construction provides long term service and stability. It also is architecturally compatible with the basic tower construction and appearance.
Wood Stairway:	
9.3 *Replace paragraph 9.3 with the following:* A 30" (762 mm) wide, column supported, 45° stairway with 8" rise and run of treated Douglas Fir shall be provided at the tower endwall rising from grade (roof) to the fan deck. Stair columns shall be nominal 4"x4". Guardrails shall be nominal 2"x4". The upper guardrail shall have an eased edge for the protection of operating personnel. Stairway foundation shall be by others, designed in accordance with drawings provided by the cooling tower manufacturer. The stairway shall conform to OSHA standards.	■ Where atmospheric conditions at the jobsite are not aggressive, the treated wood stairway may be chosen because of its lower cost.

Specifications	Specification Value
Plenum Walkway:	
9.1 *Add the following to the end of this paragraph:* Provide a 30" (762 mm) minimum wide walkway extending from one endwall access door to the other through the length of the tower. Walkway shall be constructed of fiberglass components with a nonskid surface on floor members, and the top of the walkway shall be above the cold water basin overflow level. If the cold water basin is deeper than 4'-0" (1.22 m), the walkway shall be equipped with fiberglass guardrails.	■ This option permits freedom of movement for inspection or maintenance within the tower without the need for wading boots or tower drainage. It also helps prevent maintenance personnel from damaging submerged accessories in the cold water basin (such as sump screens, probes, basin heaters, etc.). The need for guardrails where basins are deeper than 4’-0” (1.22 m) is an OSHA requirement.
Ladder Extension:	
9.4 *Add the following paragraph in the Access and Safety section:* Provide a ladder extension for connection to the base of the ladder attached to the tower casing. This extension shall be long enough to rise from the roof (grade) level to the base of the tower. Anchorage and lateral bracing of the ladder extension shall be by others.	■ Many towers are installed such that the base of the tower is 2’-0” (610 mm) or more above the roof or grade level. This makes it difficult to get up to the base of the attached ladder. The ladder extension alleviates this problem. Marley's ladder extensions are available in standard 5’-0” (1.52 m) and 11’-0” (3.35 m) lengths, and will be field-cut to fit.
Ladder Safety Cage:	
9.3 *Add the following to the end of this paragraph:* A heavy gauge galvanized steel safety cage shall surround the ladder, extending from a point approximately 7'-0" (2.13 m) above the base of the ladder to the top of the guardrail surrounding the fan deck.	■ To meet OSHA standards, towers whose fan decks are 20’-0” (6.10 m) or more above roof or grade, and which are equipped with ladders, are required to have safety cages surrounding the ladders. Their use on lower elevation towers is a matter of choice.
Hot Water Basin Covers:	
7.4 *Add the following paragraph in the Hot Water Distribution System section:* The distribution basins shall include stainless steel covers. These covers shall be designed to withstand 40 psf (1.92 kPa) live load, and shall be easily removable for maintenance.	■ These covers are designed to keep leaves and debris out of the circulating water system. They also serve to suppress algae formation by shielding the incoming hot water from direct sunlight.

Specifications	Specification Value
Air Inlet Screens:	
6.3 *Add the following paragraph in the Fill, Louvers and Drift Eliminators section:* The air inlet faces of the tower shall be covered by 1" mesh stainless steel welded wire screens. Screens shall be secured to stainless steel frames, and shall be removable.	■ In wooded or windy areas, these screens help to keep leaves or blowing debris out of the cooling tower and circulating water system.
Appearance Options	
Architectural Casing:	
8.1 *Replace paragraph 8.1 with the following:* Tower endwalls, as well as exposed hot water basin sides above the louvered face, shall be cased with horizontally-installed, pultruded fiberglass panels. Tower corners shall be finished with pultruded fiberglass angles.	■ This is an architecturally pleasing, heavy duty casing that provides an appearance similar to shiplap siding. See cover photo.
Cased Guardrail:	
8.1 *Add the following to the end of this paragraph:* The casing and corner treatment shall extend to the full height of the guardrail described in paragraph 9.2. The additional wind loading imposed by this exposure shall be accounted for in the tower's structural design.	■ Extending the casing to the top of the fan deck guardrail presents a clean architectural appearance by shielding the mechanical equipment and a major portion of the fan cylinder from view. It also offers a higher degree of protection for operation and maintenance personnel.

Specifications	Specification Value
Control Options **Control System:** 5.7 *Add the following paragraphs in the Mechanical Equipment section:* Each cell of the cooling tower shall be equipped with a UL listed control system in a NEMA 3R or 4X outdoor enclosure capable of controlling single-speed or two-speed motors as required, and designed specifically for cooling tower applications. The panel shall include a main fused disconnect with an external operating handle, lockable in the off position for safety. Across-the-line magnetic starters or solid state soft-start starters as required shall be controlled with a thermostatic or solid state temperature controller. Door mounted selector switches shall be provided to enable automatic or manual control and wired for 120VAC control. Control circuit to be wired out to terminal blocks for field connection to a remote vibration switch and for access to extra 120VAC 50VA control power, overload trip alarms and remote temperature control devices. The temperature controller shall be adjustable for the required cold water temperature. If a thermostatic controller is used it shall be mounted on the side of the tower with the temperature sensing bulb installed in the cold water basin using a suspension mounting bracket. If a solid state temperature controller is used the controller will be door mounted on the control panel. The temperature controller will display two temperatures, one for outgoing water and the other for set point. Water temperature input shall be obtained using a three-wire RTD with dry well in the outlet water piping and wired back to the solid state temperature controller in the control panel.	■ If it is your opinion that the control system for the cooling tower should be part of the tower manufacturer's responsibility, we are in wholehearted agreement with you. Who better to determine the most efficient mode and manner of a tower's operation—and to apply a system most compatible with it—than the designer and manufacturer of the cooling tower?

Specifications	Specification Value
Fan Motor Variable Speed Drive: **Marley All Weather ACH550 System** 6.4 *Add the following paragraph in the Mechanical Equipment section when VFD is used with customers Building Management System:* A complete UL listed Variable Speed Drive system in a NEMA 1 indoor, NEMA 12 indoor or NEMA 3R outdoor enclosure shall be provided. The VFD shall use PWM technology with IGBT switching and integrated bypass design. VFD out put switching shall not cause mechanical issues with gearbox teeth or drive shafts. The VFD shall catch a fan spinning in the reverse direction without tripping. The panel shall include a main disconnect with short circuit protection and external operating handle, lockable in the off position for safety. The VFD system shall receive a speed reference signal from the Building Management System monitoring the tower fluid temperature. As an option to receiving the speed reference signal from a building management system, the drive must have the capability to receive a 4-20 ma temperature signal from an RTD transmitter. The VFD shall have an internal PI regulator to modulate fan speed maintaining set point temperature. The drive's panel display shall be able to display the set-point temperature and cold-fluid temperature on two separate lines. The bypass shall include a complete magnetic bypass circuit and with capability to isolate the VFD when in the bypass mode. Transfer to the bypass mode shall be manual in the event of VFD failure. Once the motor is transferred to the by-pass circuit the fan motor will run at constant full speed. The bypass circuit will not modulate ON and OFF based on fluid temperature. The application must be able to handle very cold fluid temperatures while the VFD is in a by-pass mode. Operator controls shall be mounted on the front of the enclosure and shall consist of start and stop control, bypass/ VFD selection, Auto/Manual selections, manual speed control. To prevent heating problems in the fluid cooloer fan motor and to assure proper gear reducer lubrication the VFD system shall de energize the motor once 25% motor speed is reached	■ Marley VFD drive systems are designed to combine absolute temperature control with ideal energy management. The cooling tower user selects a cold water temperature and the drive system will vary the fan speed to maintain that temperature. Precise temperature control is accomplished with far less stress to the mechanical equipment components. The improved energy management provides fast payback. Indeed, many utilities offer generous rebates for users having installed VFD drives.

Specifications	Specification Value

and cooling is no longer required. The fluid cooler manufacturer shall supply VFD start-up assistance. Tower vibration testing throughout the speed range is required to identify and lockout any natural frequency vibration levels which may exceed CTI guidelines.

Marley Premium VFD System

6.4 *Add the following paragraph in the Mechanical Equipment section when VFD is used as a stand alone system:*
A complete UL listed Variable Speed Drive system in a NEMA 12 indoor or NEMA 3R outdoor enclosure shall be provided. The VFD shall use PWM technology with IGBT switching and integrated bypass design. VFD output switching shall not cause mechanical issues with gearbox teeth or drive shafts. The VFD shall catch a fan spinning in the reverse direction without tripping. The panel shall include a main disconnect with short circuit protection and external operating handle, lockable in the off position for safety. The system shall include a solid state, PI temperature controller to adjust frequency output of the drive in response to the tower fluid temperature. The temperature of the fluid and set point shall be displayed on the door of the control panel. The bypass shall include a complete magnetic bypass circuit with capability to isolate the VFD when in the bypass mode. Transfer to the bypass mode shall be automatic in the event of VFD failure or for specific trip conditions allowing safe transfer of utility voltage to the motor. Automatic bypass with an earth ground condition is not allowed. The bypass contactor shall be cycled on and off while operating in bypass, to maintain the set-point temperature of the cold water. The drive design shall be operated as a stand-alone system without the need for a BMS system. Operator controls shall be mounted on the front of the enclosure and shall

Specifications	Specification Value

consist of start and stop control, bypass/VFD selector switch, Auto/Manual selector switch, manual speed control, and solid-state temperature controller. An emergency bypass selector switch internal to the panel allowing the fluid cooler fan motor to be run at full speed shall be furnished. To prevent heating problems in the fluid cooler fan motor and to assure proper gear box lubrication the VFD system shall de energize the motor once 25% motor speed is reached and cooling is no longer required. The VFD shall include de-icing logic with auto canceling and adjustable time. Speed in De-Ice mode shall not exceed 50% motor speed. The fluid cooler manufacturer shall supply VFD start-up assistance. Tower vibration testing throughout the speed range is required to identify and lockout any natural frequency vibration levels which may exceed CTI guidelines.

Vibration Limit Switch:

5.5 *Add the following paragraph in the Mechanical Equipment Section:* A single-pole, double-throw vibration limit switch in a NEMA 4 housing shall be installed on the mechanical equipment support for wiring into the owner's control panel. The purpose of this switch will be to interrupt power to the motor in the event of excessive vibration. It shall be adjustable for sensitivity, and shall require manual reset.

■ Unless specified otherwise, a Marley M-5 vibration switch will be provided. The requirement for manual reset assures that the tower will be visited to determine the cause of excessive vibration.

Miscellaneous Options

Galvanized Steel Ladder:

9.3 *Change paragraph 9.3 to read as follows:* One endwall of the tower shall be equipped with an 18" (457 mm) wide hot-dip galvanized steel vertical ladder, supported by hot-dip galvanized steel brackets through-bolted to the endwall structure. Ladder shall rise from the cold water basin level to the top of the fan deck guardrail, and shall be designed and installed in conformance with OSHA standards. A horizontal-swing, gravity-closing safety bar shall be provided across the ladder opening at the fan deck.

■ This option is for those customers who either prefer steel ladders, or whose atmospheric conditions at the cooling tower location would be detrimental to aluminum.

Specifications	Specification Value
Fiberglass Ladder: 9.3 *Change paragraph 9.3 to read as follows:* One endwall of the tower shall be equipped with an 18" (457 mm) wide fiberglass vertical ladder, supported by hot-dip galvanized steel brackets through-bolted to the endwall structure. Ladder shall rise from the cold water basin level to the top of the fan deck guardrail, and shall be designed and installed in conformance with OSHA standards. A horizontal-swing, gravity-closing safety bar shall be provided across the ladder opening at the fan deck.	■ This option is for those customers who either prefer fiberglass ladders, or whose atmospheric conditions at the cooling tower location dictate its use.
Low Noise Tower: 1.1 *Add the following at the end of paragraph 1.1:* The cooling tower shall be quiet operating, and shall produce an overall level of sound no higher than ____ dBA at the critical location indicated on the Plans.	■ Sound produced by a Sigma tower operating in an unobstructed environment will meet all but the most restrictive noise limitations. Where sound levels may be considered critical, however, low noise levels can be achieved by any of several techniques. Please discuss your requirements with your local Marley sales representative.
Fire-Retardant Fiberglass: 3.7 *Add the following paragraph in the Construction section:* All fiberglass components in the cooling tower shall have a flame spread rating of 25 or less.	■ This option will affect the the standard casing panels, the plenum partitions between cells, the fan cylinders, and the optional fiberglass stairway flights and landing panels.
Fan Cylinder Extension: 4.2 *Add a third sentence in paragraph 4.2 to read as follows:* Overall fan cylinder height shall be 10 feet above the fan deck level.	■ Extended fan cylinder heights are useful where it is important to discharge the cooling tower's leaving plume at a certain elevation. This may be to avoid recirculation, or to keep the plume above a nearby structure.
Increased Wind and/or Earthquake Load:	■ If your geographic location dictates the application of higher wind and/or seismic loads, please discuss with your local Marley representative and change paragraph 3.3 to read appropriately. Please also ask for revised concrete basin or supporting steel drawings from Marley which reflect the higher load requirements.
Premium Hardware:	■ Marley can provide hardware materials suitable for all aggressive water conditions, including salt water. Please discuss with your Marley representative and change specification paragraphs appropriately.

SPX

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